USDA FOREST SERVICE
RESEARCH PAPER **NC-168**

NUTRIENT CONTENT OF SOME TALL SHRUBS FROM NORTHEASTERN MINNESOTA

D.F. Grigal, L.F. Ohmann, and N.R. Moody

North Central Forest Experiment Station
Forest Service, U.S. Department of Agriculture

Grigal, D. F., L. F. Ohmann, and N. R. Moody.
1979. Nutrient content of some tall shrubs from northeastern Minnesota. U.S. Dep. Agric. For. Serv., Res. Pap. NC-168, 10 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, Minnesota.

Presents data on nutrient content of tall shrub species from northeastern Minnesota.

OXFORD: 160.2:182.46(776). KEY WORDS: Browse, plant caloric-content, plants, energy, nutrients.

Grigal, D. F., L. F. Ohmann, and N. R. Moody.
1979. Nutrient content of some tall shrubs from northeastern Minnesota. U.S. Dep. Agric. For. Serv., Res. Pap. NC-168, 10 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, Minnesota.

Presents data on nutrient content of tall shrub species from northeastern Minnesota.

OXFORD: 160.2:182.46(776). KEY WORDS: Browse, plant caloric-content, plants, energy, nutrients.

North Central Forest Experiment Station
Robert A. Hann, Director
Forest Service — U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108
Manuscript approved for publication October 17, 1978
1979

NUTRIENT CONTENT OF SOME TALL SHRUBS FROM NORTHEASTERN MINNESOTA

D. F. Grigal, *Associate Professor,*
Departments of Soil Science and Forest Resources,
University of Minnesota, St. Paul, Minnesota

L. F. Ohmann, *Principal Plant Ecologist,*
North Central Forest Experiment Station,
St. Paul, Minnesota

and **N. R. Moody,** *formerly Research Assistant,*
Department of Forest Resources,
University of Minnesota, St. Paul, Minnesota

As part of studies of tall shrubs from northeastern Minnesota (Ohmann *et al.* 1978, Grigal *et al.* 1976, Grigal and Moody[1]), we obtained data on the nutritive value of shrubs for herbivores. In one study we collected samples of the following tall shrubs at 2-week intervals from June 15 through December 8 in the Superior National Forest of northeastern Minnesota — mountain maple (*Acer spicatum* Lam.), green alder (*Alnus crispa* [(Ait.] Pursh), juneberry (*Amelanchier* Med. [probably *humilis* Wieg.]), beaked hazel (*Corylus cornuta* Marsh.), and willow (*Salix* L. [probably *Bebbiana* Sarg.]) All species were collected from an area that had been clearcut 6 years before except *Acer,* which was collected from a nearby forest.

While still green, all plant material was separated into leaves, current year's woody twig growth (elongation), last year's twig growth, and stem including branches older than 2 years. All components were ovendried at 75C for 48 hours and weighed. The samples were ground to pass a 20-mesh sieve, again dried at 75C for 48 hours, and analyzed.

Ash content was determined by heating in a muffle furnace overnight at 525C. Phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn), and manganese (Mn) were determined by dissolving the ash in acidifed LiCl and determining concentrations by emission spectroscopy with a 1.5-m Jarrell-Ash emission spectrometer.[2] Crude protein was determined as ammonium in solution by an ammonia electrode (Bremner and Tabatabai 1972) following micro-Kjeldahl digestion. Caloric content was determined with an adiabatic bomb calorimeter (Parr Inst. Co. 1969), and crude fiber and ether extract were determined by standard procedures (Horowitz 1975). Nitrogen-free extract was determined by difference after determination of the other fractions.

In another study[1], in which we were specifically concerned with snowshoe hare (*Lepus americanus*) browse, we sampled 14 species of young trees and shrubs monthly from November through April in plantations and natural stands in northeastern Minnesota. Stems were returned to the laboratory where their diameter and length were determined. They were then separated into three quality (size) classes and the ovendry weight of material in each class was determined. The three classes were: 0- to 4-mm diameter, centered at 3 mm because most woody stems are larger than 1-mm diameter; 5- to 7-mm diameter, centered at 6 mm; and 8- to 10-mm diameter, centered at 9 mm.

[1]*D.F. Grigal and N.R. Moody. 1979. Estimation of browse by size classes for snowshoe hare. Manuscript submitted to Journal of Wildlife Management.*

[2]*Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

After weighing, subsamples of material were ground to pass a 20-mesh sieve and analyzed. Neutral detergent fiber was determined by standard procedures (Van Soest and Wine 1967), and ash, elemental concentrations, crude protein, and caloric content were determined as outlined above.

In our analysis of the data, we determined means and standard errors for each sample type for each month in which a sample was collected. In the data from Ohmann *et al.* (1978), we tested significant differences among monthly means by one way analysis of variance. For leaf elemental concentrations and quality we report overall means in all cases and monthly means where significant differences existed (tables 1 and 2). We report all monthly means whether significantly different or not for current annual growth, because of its importance as browse (tables 3 and 4). We report only overall means for stems because of the limited number of samples (table 5).

For the data from Grigal and Moody[1], we report overall means for each class (table 6). We tested whether or not significant differences existed among classes and we also tested each class on a monthly basis. Monthly differences are reported where we had sufficient samples to satisfy requirements for the tests and where differences were significant (table 7).

LITERATURE CITED

Bremner, J.M., and M.A. Tabatabai. 1972. Use of an ammonia electrode for determination of ammonium in Kjeldahl analysis of soils. Soil Sci. Plant Anal. 3:159-165.

Grigal, D.F., L.F. Ohmann, and R.B. Brander. 1976. Seasonal dynamics of tall shrubs in northeastern Minnesota: biomass and nutrient element changes. For. Sci. 22:195-208.

Horowitz, W. ed. 1975. Official methods of analysis. 1,094 p. 12th ed. Assoc. Offic. Anal. Chem., Washington, D.C.

Ohmann, L.F., D.F. Grigal, and R.B. Brander. 1978. Shrub mass: data variability and changes over time. p. 172-214. *In* Tenth North American Moose Conf. Proc., Duluth, Minnesota, 1974. 316 p. Minnesota Department Natural Resources.

Parr Instrument Company. 1969. Instructions for 1241 and 1242 adiabatic calorimeters. Manual 142, 23 p. Parr Instrument Co., Moline, Illinois.

Van Soest, P.J., and R.H. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of cell-wall constituents. J. Assoc. Offic. Anal. Chem. 50(1):50-55.

Table 1.—*Elemental concentrations of tall shrub leaves (Ohmann* et al. *1978) — significant differences in monthly values indicated at 0.05 (*) or 0.01 (**) level*

(Standard errors in parentheses)

Species	Month	P	K	Ca	Mg	Fe	Cu	Zn	Mn
		percent dry weight				mg/kg			
Mountain maple	All	0.50	1.56	1.27 **	0.05 **	282. *	11.8 **	49.	560.
		(.026)	(.076)	(.094)	(.029)	(12.0)	(.01)	(3.2)	(40.5)
	June	—	—	.79	.38	220.	16.1	—	—
		—	—	(.046)	(.035)	(15.2)	(.01)	—	—
	July	—	—	1.05	.42	296.	13.8	—	—
		—	—	(.118)	(.032)	(28.5)	(.02)	—	—
	Aug.	—	—	1.24	.54	291.	10.0	—	—
		—	—	(.074)	(.034)	(11.0)	(.01)	—	—
	Sept.	—	—	2.02	.64	318.	8.3	—	—
		—	—	(.084)	(.073)	(31.2)	(.01)	—	—
Green alder	All	.23 **	.74 **	.91	.24	239. **	9.1 **	38.	697.
		(.009)	(.034)	(.032)	(.007)	(12.3)	(.55)	(2.4)	(57.2)
	June	.29	.99	—	—	193.	13.0	—	—
		(.010)	(.070)	—	—	(9.7)	(.78)	—	—
	July	.23	.72	—	—	209.	10.3	—	—
		(.011)	(.034)	—	—	(18.6)	(.79)	—	—
	Aug.	.20	.64	—	—	238.	7.3	—	—
		(.012)	(.033)	—	—	(17.1)	(.24)	—	—
	Sept.	.20	.65	—	—	316.	6.9	—	—
		(.007)	(.044)	—	—	(24.9)	(.64)	—	—
Juneberry	All	.45	1.48	1.30 **	.44 *	154. *	11.0 *	72. *	1,327.
		(.025)	(.064)	(.054)	(.013)	(8.1)	(.79)	(3.2)	(70.8)
	June	—	—	1.04	.49	129.	14.7	87.	—
		—	—	(.081)	(.032)	(10.5)	(2.10)	(7.8)	—
	July	—	—	1.16	.48	138.	12.0	62.	—
		—	—	(.118)	(.020)	(11.3)	(1.64)	(4.4)	—
	Aug.	—	—	1.41	.42	152.	9.0	67.	—
		—	—	(.055)	(.015)	(8.6)	(.78)	(4.4)	—
	Sept.	—	—	1.55	.39	198.	9.3	75.	—
		—	—	(.083)	(.029)	(23.2)	(1.15)	(6.9)	—
Beaked hazel	All	.33 *	.86 *	1.48 *	.37 **	288. **	9.6 **	32.	1,779.
		(.012)	(.046)	(.077)	(.013)	(20.8)	(.69)	(6.2)	(113.1)
	June	.37	1.10	1.42	.41	199.	13.2	—	—
		(.024)	(.031)	(.133)	(.029)	(12.5)	(1.19)	—	—
	July	.33	.87	1.29	.38	255.	11.2	—	—
		(.019)	(.051)	(.087)	(.019)	(16.2)	(1.32)	—	—
	Aug.	.29	.79	1.37	.32	304.	7.5	—	—
		(.019)	(.087)	(.089)	(.008)	(31.5)	(.71)	—	—
	Sept.	.36	.70	1.97	.42	406.	7.3	—	—
		(.015)	(.107)	(.228)	(.028)	(59.1)	(.87)	—	—
Willow	All	.31 **	1.05 *	1.21 **	.32	162. *	8.4 **	137. *	536.
		(.030)	(.082)	(.087)	(.015)	(9.3)	(.83)	(18.8)	(96.7)
	June	.50	1.48	.72	—	136.	13.7	209.	—
		(.073)	(.096)	(.093)	—	(11.6)	(1.90)	(39.5)	—
	July	.29	.99	.93	—	155.	8.1	211.	—
		(.026)	(.278)	(.230)	—	(32.3)	(.94)	(60.1)	—
	Aug.	.26	.96	1.47	—	153.	6.4	88.	—
		(.017)	(.131)	(.069)	—	(15.0)	(.62)	(16.9)	—
	Sept.	.21	.79	1.46	—	205.	6.3	100.	—
		(.014)	(.077)	(.136)	—	(13.0)	(.58)	(31.3)	—

Table 2.— *Quality parameters for tall shrub leaves (Ohmann* et al. *1978) — significant differences in monthly values indicated at 0.05 (*) or 0.01 (**) level or not significant (NS)*
(Standard errors in parentheses)

Species	Month	Energy	Ash	Protein	Ether extract	Crude fiber	N-Free extract
		cal/g	*Percent dry weight*				
Mountain maple	All	—	7.4 **	14.1 *	2.8 NS	12.8 NS	62.8 NS
		—	(.29)	(.57)	(.16)	(.21)	(.67)
	June	—	6.4	15.0	3.3	12.9	62.3
		—	(.25)	(.58)	(.36)	(.34)	(.69)
	July	—	6.5	16.7	2.3	13.0	61.5
		—	(.66)	(1.67)	(.46)	(.39)	(2.12)
	Aug.	4,452	7.6	12.6	2.7	12.5	64.6
		(1.9)	(.30)	(.72)	(.13)	(.46)	(1.19)
	Sept.	—	9.1	13.0	3.1	12.8	61.9
		—	(.38)	(.87)	(.31)	(.47)	(.88)
Green alder	All	—	4.4 *	17.0 **	4.8 NS	13.2 NS	60.6 NS
		—	(.15)	(.66)	(.25)	(.29)	(.81)
	June	—	4.2	19.2	4.6	12.1	60.0
		—	(.29)	(.54)	(.66)	(.30)	(1.01)
	July	—	4.1	20.0	4.0	14.0	57.9
		—	(.18)	(1.09)	(.31)	(.54)	(1.48)
	Aug.	4,992	4.3	15.0	4.8	13.0	63.0
		(35.1)	(.24)	(1.09)	(.22)	(.59)	(1.66)
	Sept.	—	5.2	15.0	5.7	13.7	60.4
		—	(.34)	(1.08)	(.72)	(.55)	(1.54)
Beaked hazel	All	—	6.4 **	13.2 **	1.6 **	14.0 **	64.8 NS
		—	(.23)	(.75)	(.18)	(.40)	(.54)
	June	—	6.2	16.7	.60	12.0	64.5
		—	(.34)	(1.40)	(.09)	(.49)	(1.01)
	July	—	5.7	15.9	1.4	14.0	63.1
		—	(.27)	(.47)	(.16)	(.51)	(1.15)
	Aug.	4,513	6.2	11.2	2.3	14.5	65.9
		(21.9)	(.39)	(.92)	(.36)	(.72)	(.96)
	Sept.	—	8.0	9.1	1.6	15.8	65.4
		—	(.32)	(.78)	(.28)	(.57)	(1.02)
Juneberry	All	—	7.0 NS	13.7 **	4.1 *	14.7 NS	60.4 NS
		—	(.15)	(.64)	(.22)	(.33)	(.68)
	June	—	6.7	15.9	3.3	15.0	59.1
		—	(.25)	(.93)	(.33)	(.92)	(1.44)
	July	—	6.7	16.8	3.5	14.7	58.2
		—	(.35)	(.94)	(.36)	(.37)	(1.25)
	Aug.	4,835	7.1	12.0	4.8	14.6	61.6
		(63.2)	(.23)	(.49)	(.42)	(.50)	(.85)
	Sept.	—	7.3	10.8	4.7	14.7	62.5
		—	(.36)	(1.20)	(.30)	(.95)	(1.57)
Willow	All	—	5.3 NS	13.2 **	3.9 NS	12.4 NS	65.3 *
		—	(.15)	(.90)	(.27)	(.32)	(.75)
	June	—	4.9	17.9	3.6	11.4	62.2
		—	(.28)	(1.26)	(.64)	(.42)	(.57)
	July	—	4.7	16.4	3.7	12.4	62.8
		—	(.48)	(2.85)	(1.05)	(1.04)	(3.20)
	Aug.	4,838	5.7	11.5	3.7	12.2	66.9
		(115.4)	(.22)	(.71)	(.23)	(.44)	(.96)
	Sept.	—	5.2	9.4	4.6	13.6	67.2
		—	(.23)	(1.11)	(.69)	(.77)	(1.28)

Table 3.—*Elemental concentrations of tall shrub current twigs (Ohmann* et al. *1978) — significant differences in monthly values indicated at 0.05 (*) or 0.01 (**) level or not significant (NS) (Standard errors in parentheses)*

Species	Month	P	K	Ca	Mg	Fe	Cu	Zn	Mn
		Percent dry weight				(mg/kg)			
Mountain maple	All	.18 **	.83 **	.91 NS	.19 **	48. **	7.8 **	49. NS	332. NS
		(.010)	(.114)	(.025)	(.012)	(3.8)	(.70)	(3.1)	(20.2)
	June	.31	2.24	.82	.30	82.	14.5	53.	376.
		(.024)	(.231)	(.052)	(.036)	(14.1)	(1.83)	(3.8)	(59.6)
	July	.19	1.12	.86	.19	33.	10.1	49.	329.
		(.014)	(.165)	(.061)	(.026)	(4.9)	(.99)	(9.7)	(73.7)
	Aug.	.14	.58	.90	.18	37.	7.2	49.	300.
		(.006)	(.047)	(.062)	(.017)	(3.3)	(.96)	(10.0)	(36.6)
	Sept.	.14	.38	.99	.14	31.	4.5	37.	318.
		(.011)	(.011)	(.061)	(.012)	(3.0)	(.41)	(2.9)	(35.6)
	Oct.	.18	.40	1.03	.16	49.	4.8	50.	396.
		(.006)	(.023)	(.054)	(.011)	(4.4)	(.70)	(6.9)	(62.7)
	Nov.	.16	.40	.88	.17	71.	6.9	56.	298.
		(.013)	(.035)	(.014)	(.021)	(7.3)	(3.70)	(2.9)	(38.4)
	Dec.	.14	.34	.86	.17	51.	5.5	49.	283.
		(.005)	(.017)	(.086)	(.014)	(5.2)	(.75)	(11.6)	(56.8)
Green alder	All	.20 **	.50 **	.87 **	.15 **	74. **	9.8 *	57. NS	485. **
		(.013)	(.052)	(.036)	(.010)	(3.9)	(.63)	(3.0)	(41.9)
	June	.36	1.11	1.03	.26	113.	13.0	70.	733.
		(.014)	(.097)	(.055)	(.012)	(5.5)	(2.73)	(6.9)	(94.8)
	July	.25	.68	1.01	.20	70.	12.8	63.	752.
		(.013)	(.042)	(.095)	(.011)	(7.2)	(1.45)	(7.6)	(126.3)
	Aug.	.15	.35	.73	.11	56.	8.6	46.	395.
		(.008)	(.022)	(.049)	(.006)	(5.7)	(.67)	(5.2)	(70.8)
	Sept.	.13	.26	.80	.11	59.	7.6	46.	321.
		(.004)	(.008)	(.032)	(.002)	(5.2)	(.74)	(4.6)	(42.4)
	Oct.	.16	.30	.69	.11	72.	8.7	62.	358.
		(.002)	(.013)	(.043)	(.003)	(7.8)	(.46)	(9.3)	(64.2)
	Nov.	.17	.32	.86	.11	75.	7.3	51.	383.
		(.011)	(.018)	(.172)	(.003)	(6.8)	(.47)	(8.1)	(98.8)
	Dec.	.17	.29	1.10	.11	78.	9.4	71.	389.
		(.014)	(.017)	(.201)	(.003)	(10.3)	(2.28)	(7.7)	(77.0)

(Continued on next page)

(Table 3 continued)

Species	Month	P	K	Ca	Mg	Fe	Cu	Zn	Mn
		Percent dry weight				(mg/kg)			
Beaked hazel	All	.18 **	.80 **	1.21 NS	.18 **	99. **	11.7 NS	63. **	1098. NS
		(.012)	(.046)	(.038)	(.011)	(5.7)	(.47)	(4.5)	(54.0)
	June	.31	1.37	1.25	.31	118.	14.9	107.	1153.
		(.042)	(.138)	(.108)	(.028)	(19.6)	(1.66)	(10.9)	(98.2)
	July	.17	.79	1.21	.22	73.	11.4	62.	1054.
		(.013)	(.045)	(.127)	(.021)	(1.9)	(1.11)	(7.6)	(127.9)
	Aug.	.14	.70	1.09	.15	72.	10.1	45.	990.
		(.007)	(.024)	(.086)	(.007)	(6.7)	(.75)	(4.6)	(108.3)
	Sept.	.16	.66	1.26	.14	115.	12.4	56.	1368.
		(.010)	(.033)	(.059)	(.007)	(15.1)	(1.22)	(6.5)	(235.4)
	Oct.	.16	.63	1.15	.14	113.	10.9	61.	1063.
		(.005)	(.019)	(.043)	(.008)	(12.2)	(.88)	(13.0)	(62.4)
	Nov.	.15	.61	1.15	.12	93.	10.5	56.	897.
		(.011)	(.045)	(.059)	(.007)	(6.1)	(.90)	(14.8)	(54.8)
	Dec.	.16	.74	1.56	.15	139.	12.5	59.	1123.
		(.009)	(.051)	(.023)	(.013)	(12.1)	(.72)	(5.1)	(184.2)
Juneberry	All	.18 **	.61 **	.82 NS	.17 **	34. **	9.7 NS	68. NS	311. NS
		(.014)	(.066)	(.030)	(.008)	(2.7)	(.63)	(3.0)	(18.5)
	June	.35	1.45	.68	.25	26.	13.9	83.	436.
		(.043)	(.153)	(.050)	(.024)	(3.0)	(1.98)	(10.6)	(46.5)
	July	.17	.72	.72	.16	26.	10.2	56.	302.
		(.018)	(.080)	(.028)	(.009)	(7.6)	(1.84)	(4.6)	(48.1)
	Aug.	.13	.40	.86	.14	25.	8.8	65.	303.
		(.008)	(.010)	(.065)	(.012)	(3.9)	(1.11)	(4.9)	(40.3)
	Sept.	.14	.38	.86	.15	29.	9.6	62.	246.
		(.006)	(.028)	(.082)	(.014)	(4.2)	(1.29)	(3.0)	(37.6)
	Oct.	.18	.41	.88	.17	44.	9.6	77.	300.
		(.009)	(.045)	(.064)	(.007)	(3.8)	(.97)	(8.9)	(47.3)
	Nov.	.16	.46	.98	.13	58.	6.0	65.	258.
		(.004)	(.027)	(.234)	(.006)	(10.4)	(2.24)	(19.2)	(47.5)
	Dec.	.18	.36	.85	.16	62.	7.2	66.	302.
		(.010)	(.018)	(.036)	(.005)	(2.3)	(.40)	(3.2)	(29.1)
Willow	All	.20 **	.72 **	.80 NS	.13 **	124. NS	9.6 *	164. NS	215. NS
		(.019)	(.117)	(.029)	(.009)	(20.0)	(.75)	(12.7)	(38.4)
	June	.42	2.16	.86	.22	69.	14.5	219.	303.
		(.063)	(.234)	(.093)	(.024)	(7.4)	(.96)	(45.4)	(156.0)
	July	.18	.70	.75	.15	51.	12.4	233.	483.
		(.014)	(.051)	(.110)	(.030)	(8.6)	(1.44)	(77.5)	(328.4)
	Aug.	.14	.53	.84	.11	78.	9.8	114.	129.
		(.011)	(.065)	(.047)	(.011)	(16.3)	(2.11)	(9.5)	(25.1)
	Sept.	.15	.38	.76	.10	193.	7.9	141.	150.
		(.012)	(.022)	(.065)	(.006)	(102.4)	(.98)	(19.4)	(20.4)
	Oct.	.17	.31	.76	.11	157.8	6.7	170.	201.
		(.006)	(.011)	(.072)	(.006)	(29.5)	(.37)	(18.6)	(26.0)
	Nov.	.18	.34	.82	.10	167.	6.3	147.	222.
		(.021)	(.005)	(.127)	(.008)	(23.2)	(2.54)	(29.2)	(87.2)
	Dec.	.16	.31	.75	.09	192.	8.7	183.	180.
		(.011)	(.003)	(.129)	(.007)	(70.5)	(.34)	(45.4)	(12.3)

Table 4.— *Quality parameters for tall shrub current twigs (Ohmann* et al. *1978) — significant differences in monthly values indicated at 0.05 (*) or 0.01 (**) level or not significant (NS)*
(Standard errors in parentheses)

Species	Month	Energy	Ash	Protein	Ether extract	Crude fiber	N-free extract
		cal/g	*Percent dry weight*				
Mountain maple	All	4,662 *	3.5 **	6.2 **	2.0 NS	36.8 *	51.4 NS
		(40.2)	(.19)	(.38)	(.09)	(.77)	(.49)
	June	4,518	6.4	10.6	1.7	29.0	52.5
		(13.5)	(.37)	(2.77)	(.13)	(1.71)	(1.14)
	July	4,638	4.0	7.3	2.0	35.9	50.7
		(19.6)	(.28)	(.44)	(.15)	(2.16)	(1.68)
	Aug.	4,628	3.4	5.1	2.0	37.9	51.6
		(41.8)	(.21)	(.38)	(.20)	(1.31)	(.92)
	Sept.	4,680	3.0	5.0	2.2	39.0	50.8
		(39.7)	(.18)	(.38)	(.20)	(1.73)	(1.36)
	Oct.	4,687	3.1	6.0	2.2	36.4	52.2
		(2.1)	(.23)	(.50)	(.32)	(1.57)	(1.17)
	Nov.	[1] 4,705	3.5	6.4	1.3	37.3	51.5
		—	(.07)	(.98)	(.07)	(1.46)	(1.50)
	Dec.	4,746	2.2	4.9	2.5	39.3	51.0
		(28.6)	(.18)	(.07)	(.09)	(2.28)	(2.37)
Green alder	All	5,091 **	3.1 **	9.2 **	5.7 **	21.9 *	60.1 NS
		(51.9)	(.22)	(.24)	(.37)	(.38)	(.35)
	June	4,766	6.2	11.4	2.9	18.6	60.9
		(6.5)	(.83)	(.56)	(.69)	(2.60)	(3.0)
	July	4,802	3.9	10.5	2.9	22.3	60.4
		(61.5)	(.33)	(1.17)	(.21)	(.93)	(.72)
	Aug.	5,054	2.6	8.7	5.2	23.6	59.8
		(56.3)	(.19)	(.17)	(.49)	(.60)	(.62)
	Sept.	5,159	2.5	8.4	7.8	21.3	60.1
		(19.3)	(.09)	(.21)	(.52)	(.45)	(.62)
	Oct.	5,174	2.2	9.2	6.5	22.0	60.1
		(35.5)	(.20)	(.31)	(.35)	(.65)	(.63)
	Nov.	[1]5,189	3.0	8.4	6.0	21.3	61.3
		—	(.37)	(.37)	(.27)	(.57)	(.72)
	Dec.	5,181	2.7	8.9	8.8	21.6	57.9
		(33.2)	(.38)	(.11)	(.38)	(.99)	(.82)
Beaked hazel	All	4,546 **	4.2 NS	7.0 **	1.9 **	24.6 NS	62.2 NS
		(34.1)	(.11)	(.31)	(.10)	(.35)	(.44)
	June	4,314	5.1	10.3	.82	23.2	60.6
		(64.0)	(.27)	(2.47)	(.28)	(1.62)	(.29)
	July	4,496	4.3	8.9	1.4	25.2	60.2
		(50.0)	(.37)	(.89)	(.21)	(1.19)	(2.06)
	Aug.	4,530	3.9	6.0	2.2	24.6	63.3
		(22.2)	(.26)	(.40)	(.20)	(.79)	(.66)
	Sept.	4,624	4.3	6.3	2.2	24.1	63.2
		(9.9)	(.17)	(.36)	(.11)	(.81)	(.81)
	Oct.	4,549	4.2	7.3	2.1	25.6	60.8
		(11.0)	(.20)	(.22)	(.22)	(.72)	(.56)
	Nov.	[1]4,652	4.5	6.8	1.7	24.0	63.0
		—	(.36)	(.41)	(.13)	(.60)	(.68)
	Dec.	4,622	4.4	6.0	1.9	23.7	64.1
		(12.0)	(.02)	(.16)	(.18)	(.63)	(.69)

(Continued on next page)

(Table 4 continued)

Species	Month	Energy	Ash	Protein	Ether extract	Crude fiber	N-free extract
		cal/g	*Percent dry weight*				
Juneberry	All	4,715 **	3.1 **	6.1 **	2.2 **	29.7 NS	58.9 *
		(35.1)	(.12)	(.35)	(.16)	(.56)	(.61)
	June	4,588	4.4	12.2	1.6	27.7	54.1
		(51.0)	(.03)	(3.06)	(.25)	(.17)	(2.62)
	July	4,661	3.1	6.1	2.3	32.8	55.7
		(26.5)	(.17)	(.61)	(.23)	(1.56)	(2.12)
	Aug.	4,668	2.9	4.7	1.9	29.3	61.1
		(25.8)	(.19)	(.34)	(.30)	(1.26)	(1.09)
	Sept.	4,724	2.8	5.6	2.2	30.2	59.2
		(22.4)	(.18)	(.27)	(.21)	(.67)	(.45)
	Oct.	4,758	3.1	6.8	1.9	29.4	58.8
		(10.0)	(.12)	(.19)	(.20)	(1.42)	(1.06)
	Nov.	[1]4,829	4.2	5.4	1.7	27.0	61.6
		—	(.58)	(.19)	(.58)	(2.12)	(1.13)
	Dec.	4,851	2.6	6.4	4.2	28.8	58.0
		(15.7)	(.02)	(.20)	(.36)	(1.02)	(1.23)
Willow	All	4,995 **	3.3 **	6.6 **	3.2 **	30.7 **	56.2 NS
		(52.8)	(.21)	(.30)	(.16)	(.60)	(.41)
	June	4,740	6.2	9.7	2.1	23.8	58.3
		(30.6)	(.43)	(1.14)	(.18)	(1.16)	(1.47)
	July	4,814	3.2	7.9	2.7	28.9	57.3
		—	(.24)	(.96)	(.34)	(1.34)	(2.33)
	Aug.	4,942	3.2	5.3	2.9	32.5	56.1
		(79.8)	(.21)	(.32)	(.26)	(.58)	(.44)
	Sept.	5,064	2.7	5.9	3.7	32.2	55.5
		(15.0)	(.25)	(.42)	(.21)	(.93)	(.86)
	Oct.	5,096	2.7	6.9	3.7	31.9	54.8
		(54.0)	(.13)	(.22)	(.23)	(1.09)	(.85)
	Nov.	[1]5,100	3.2	6.7	2.8	31.7	55.6
		—	(.33)	(.46)	(.21)	(1.42)	(2.24)
	Dec.	5,094	2.1	6.3	4.8	29.6	57.3
		(15.4)	(.28)	(.31)	(.22)	(1.42)	(1.06)

[1]No standard error calculated because energy values are based on single sample.

Table 5.—*Elemental concentrations of tall shrub stems (Ohmann* et al. *1978)*
(Standard errors in parentheses)

Species	Month	P	K	Ca	Mg	Fe	Cu	Zn	Mn
		percent dry weight				*mg/kg*			
Mountain maple	All	.04	.14	.34	.05	35	3.1	23	106
		(.002)	(.006)	(.012)	(.002)	(1.5)	(.20)	(1.2)	(8.7)
Green alder	All	.06	.14	.38	.05	58	5.1	41	152
		(.003)	(.006)	(.018)	(.002)	(4.0)	(.29)	(3.5)	(12.6)
Beaked hazel	All	.08	.22	.61	.05	79	6.4	46	447
		(.004)	(.006)	(.021)	(.002)	(3.9)	(.30)	(5.3)	(25.3)
Juneberry	All	.06	.17	.41	.05	46	6.3	40	159
		(.003)	(.008)	(.016)	(.002)	(4.8)	(.40)	(2.2)	(11.1)
Willow	All	.06	.14	.58	.05	34	5.0	86	85
		(.002)	(.007)	(.027)	(.018)	(2.4)	(.26)	(5.4)	(7.8)

Table 6.— *Quality parameters and elemental concentrations of tall shrub and tree twigs (Grigal and Moody)— significant differences in size classes indicated at 0.05 (*) or 0.01 (**) level or not significant (NS)* (Standard error in parentheses).

Species	Size	Energy	Fiber	Ash	Protein	P	K	Ca	Mg	Fe	Cu	Zn	Mn
	mm	(cal/g)	Percent dry weight							mg/kg			
Red maple (*Acer rubrum*)	≤4	4,523 NS	58 **	3.1 NS	7.7 NS	.15**	.38 *	1.00**	.10**	64 *	5.6**	39 NS	424 NS
		(44.5)	(0.9)	(.24)	(.89)	(.019)	(.044)	(.087)	(.004)	(10.1)	(.55)	(8.9)	(141.6)
	5 to 7	4,567	67	2.6	6.6	.09	.32	.74	.08	45	4.6	30	332
		(56.5)	(2.3)	(.12)	(.44)	(.006)	(.035)	(.048)	(.003)	(4.3)	(.18)	(4.9)	(98.9)
	8 to 10	4,531	81	1.7	6.8	.06	.21	.41	.05	22	3.1	20	198
		(42.5)	(0.8)	(.38)	(1.10)	(.001)	(.025)	(.061)	(.002)	(4.7)	(.30)	(6.0)	(72.6)
Mountain maple	≤4	4,762 *	59 **	4.2**	7.1 NS	.12**	.37**	1.39**	.12**	81 **	4.4 NS	61 **	276 **
		(89.2)	(1.2)	(.21)	(.55)	(.005)	(.009)	(.053)	(.004)	(10.9)	(.28)	(5.4)	(22.1)
	5 to 7	4,573	68	2.8	5.9	.08	.26	.96	.07	52	4.2	43	165
		(54.5)	(0.7)	(.15)	(.21)	(.004)	(.008)	(.042)	(.003)	(8.4)	(.59)	(2.8)	(17.7)
	8 to 10	4,521	76	2.1	5.9	.06	.20	.70	.05	37	3.3	33	125
		(36.9)	(2.1)	(.06)	(.39)	(.003)	(.007)	(.026)	(.003)	(6.8)	(.37)	(1.7)	(13.3)
Green alder	≤4	4,873 NS	58 NS	3.0 NS	8.5 NS	.12 *	.29**	.97 NS	.11**	85 NS	7.7**	54 NS	138 NS
		(45.5)	(3.1)	(.34)	(.44)	(.013)	(.025)	(.123)	(.009)	(17.0)	(.45)	(14.7)	(29.0)
	5 to 7	4,758	65	2.3	6.8	.09	.21	.71	.07	68	5.1	38	89
		(45.3)	(4.0)	(.35)	(.43)	(.008)	(.011)	(.094)	(.001)	(19.0)	(.56)	(12.3)	(16.5)
	8 to 10	4,738	68	2.1	6.7	.08	.18	.65	.07	63	4.6	37	75
		(48.3)	(2.0)	(.40)	(.65)	(.009)	(.013)	(.095)	(.002)	(14.8)	(.35)	(12.3)	(15.1)
Speckled alder (*Alnus rugosa*)	≤4	5,024 NS	59 **	2.6**	9.3**	.11**	.31**	.76 NS	.12**	125 NS	10.8**	121 **	235 NS
		(79.6)	(1.5)	(.13)	(.48)	(.006)	(.018)	(.068)	(.005)	(8.1)	(.81)	(6.7)	(31.4)
	5 to 7	4,918	65	2.1	7.1	.08	.24	.63	.08	106	6.7	89	199
		(55.8)	(1.8)	(.11)	(.37)	(.004)	(.012)	(.046)	(.003)	(13.2)	(.47)	(9.5)	(20.2)
	8 to 10	4,811	70	1.8	6.1	.07	.22	.61	.08	105	5.3	75	213
		(56.8)	(1.4)	(.07)	(.57)	(.006)	(.016)	(.058)	(.004)	(16.6)	(.35)	(12.6)	(34.9)
Juneberry	≤ 4	4,778 **	67 **	2.9 NS	7.1 NS	.10 NS	.34 *	.89 NS	.12**	71 **	8.2 *	64 NS	138 NS
		(22.0)	(1.6)	(.39)	(.58)	(.015)	(.035)	(.137)	(.015)	(4.7)	(.92)	(8.8)	(40.3)
	5 to 7	4,641	77	2.3	5.9	.08	.28	.71	.09	47	6.9	43	89
		(35.3)	(2.1)	(.35)	(.17)	(.014)	(.031)	(.121)	(.009)	(4.8)	(.71)	(7.3)	(38.3)
	8 to 10	4,479	82	1.8	6.1	.06	.22	.57	.06	39	5.2	39	82
		(37.3)	(1.1)	(.12)	(.13)	(.011)	(.021)	(.031)	(.004)	(2.9)	(.35)	(7.5)	(38.9)
Bog birch (*Betula pumila*)	≤4	4,940 **	69 NS	1.8**	7.7 NS	.09**	.22 *	.47 NS	.10**	227 **	6.3 NS	240 **	162 NS
		(30.4)	(1.3)	(.10)	(.91)	(.006)	(.011)	(.042)	(.007)	(34.8)	(.35)	(19.9)	(18.7)
	5 to 7	4,770	77	1.5	6.6	.07	.17	.35	.08	132	4.7	179	123
		(31.3)	(2.1)	(.18)	(.40)	(.005)	(.009)	(.035)	(.004)	(21.4)	(.55)	(14.2)	(16.2)
	8 to 10	4,761	77	1.1	6.5	.06	.16	.36	.07	115	5.3	161	104
		(28.0)	(4.3)	(.06)	(.75)	(.006)	(.020)	(.064)	(.009)	(15.3)	(1.39)	(10.6)	(16.5)
Dogwoods (*Cornus spp.*)	≤4	4,662 *	56 **	3.8**	6.5 NS	.14 NS	.33**	1.26**	10**	70 *	5.7 NS	38 **	28 NS
		(87.4)	(2.1)	(.19)	(.69)	(.018)	(.017)	(.083)	(.008)	(7.0)	(.74)	(7.0)	(7.8)
	5 to 7	4,543	63	3.0	6.2	.13	.28	1.02	.07	44	4.5	20	15
		(23.5)	(2.5)	(.16)	(.68)	(.019)	(.019)	(.050)	(.006)	(5.1)	(.63)	(2.9)	(6.6)
	8 to 10	4,378	67	2.2	5.3	.11	.23	.79	.05	40	5.2	15	11
		(89.3)	(2.1)	(.25)	(.91)	(.022)	(.017)	(.056)	(.006)	(9.9)	(1.85)	(4.0)	(4.7)
Beaked hazel	≤4	4,535 NS	64 **	4.5**	7.0 NS	.11**	.53**	1.29**	.12**	122 **	8.9**	65 **	495 **
		(17.2)	(1.2)	(.12)	(.36)	(.005)	(.024)	(.056)	(.005)	(6.9)	(.76)	(5.3)	(59.3)
	5 to 7	4,503	76	3.4	6.2	.08	.31	1.01	.08	101	6.4	38	279
		(49.4)	(1.1)	(.13)	(.22)	(.005)	(.012)	(.052)	(.003)	(8.7)	(.69)	(3.6)	(37.3)
	8 to 10	4,501	78	2.7	6.5	.07	.23	.85	.06	62	4.5	21	235
		(26.6)	(2.1)	(.15)	(.37)	(.003)	(.009)	(.048)	(.002)	(5.1)	(.25)	(4.1)	(28.8)

(Continued on next page)

(Table 6 continued)

Species	Size	Energy	Fiber	Ash	Protein	P	K	Ca	Mg	Fe	Cu	Zn	Mn
	mm	(cal/g)	Percent dry weight							mg/kg			
Quaking aspen (*Populus tremuloides*)	≤4	4,566 NS	69 *	4.1 NS	9.4 NS	.12 *	.34 NS	1.32 NS	.12 **	79 NS	8.5 NS	29 NS	77 *
		(40.2)	(2.6)	(.46)	(2.08)	(.006)	(.033)	(.140)	(.003)	(11.4)	(.99)	(5.7)	(16.8)
	5 to 7	4,537	76	3.5	7.6	.10	.26	.92	.08	60	6.0	23	43
		(29.5)	(0.8)	(1.08)	(1.95)	(.015)	(.061)	(.297)	(.014)	(3.8)	(1.27)	(5.0)	(2.2)
	8 to 10	4,548	81	2.1	6.0	.07	.19	.55	.05	42	3.9	18	28
		(15.3)	(2.2)	(.20)	(1.16)	(.003)	(.029)	(.059)	(.002)	(7.3)	(.84)	(4.8)	(6.7)
Willow	≤4	4,909 NS	59 **	2.1 NS	9.2 NS	.13 *	.28 NS	.44 NS	.17 *	70 NS	7.3 NS	231 NS	551 NS
		(73.9)	(0.4)	(.05)	(.93)	(.010)	(.018)	(.049)	(.006)	(5.5)	(1.45)	(22.4)	(104.4)
	5 to 7	4,779	66	1.9	7.5	.11	.23	.41	.14	68	5.3	199	578
		(100.6)	(1.1)	(.02)	(.79)	(.008)	(.020)	(.026)	(.011)	(7.4)	(.95)	(19.8)	(86.2)
	8 to 10	4,759	71	1.9	6.9	.08	.20	.36	.12	52	5.2	166	494
		(34.5)	(1.9)	(.16)	(.57)	(.013)	(.035)	(.033)	(.015)	(10.5)	(.69)	(19.3)	(79.3)

Table 7.— *Quality parameters and elemental concentrations of tall shrub twigs (Grigal and Moody)*
(Standard errors in parentheses)

Species	Size	Parameter	Dec	Jan	Feb	Mar
	(mm)					
Mountain maple	5 to 7	K (% dry wt)	[1].21	.28	.26	.25
			(.005)	(.008)	(.001)	(.010)
	8 to 10	P (% dry wt)	[2].05	.07	.07	.07
			(.001)	(.003)	(.005)	(.002)
	8 to 10	Fe (mg/kg)	[2]15.	36.	79.	21.
			(.5)	(4.1)	(34.5)	(8.0)
	8 to 10	Cu (mg/kg)	[1]2.6	3.9	4.0	0.9
			(.65)	(.35)	(.25)	(.05)
Beaked hazel	≤4	Fiber (% dry wt)	[2]68.	66.	59.	61.
			(0.6)	(2.1)	(1.5)	(0.7)
	≤4	P (% dry wt)	[2]0.10	0.10	0.12	0.15
			(.005)	(.005)	(.008)	(.025)
	≤4	Fe (mg/kg)	[2]89.	138.	98.	114.
			(8.8)	(8.2)	(2.1)	(6.8)
	5 to 7	P (% dry wt)	[2].07	.08	.11	.11
			(.006)	(.005)	(.012)	(.031)
	5 to 7	K (% dry wt)	[2].30	.31	.40	.27
			(.013)	(.013)	(.061)	(.015)
	5 to 7	Fe (mg/kg)	[2].62	119.	76.	86.
			(9.3)	(11.2)	(13.6)	(22.6)
	8 to 10	Protein (% dry wt)	[2]5.3	6.9	8.2	4.6
			(.05)	(.49)	(.37)	(.57)
	8 to 10	Fe (mg/kg)	[2]30.	72.	63.	56.
			(3.0)	(6.8)	(4.6)	(3.2)

[1]Significant differences in monthly values indicated at 0.01 level.
[2]Significant differences in monthly values indicated at 0.05 level.

☆U.S. GOVERNMENT PRINTING OFFICE: 1979-666-